Impact of Different Sarcopenia Stages on the Postoperative New Osteoporotic Vertebral Compression Fracture After Percutaneous Kyphoplasty

Chaowei Lin
  Wenzhou Medical University First Affiliated Hospital: The First Affiliated Hospital of Wenzhou Medical University

Minyu Zhu
  Wenzhou Medical University First Affiliated Hospital: The First Affiliated Hospital of Wenzhou Medical University

Kelun Huang
  Wenzhou Medical University First Affiliated Hospital: The First Affiliated Hospital of Wenzhou Medical University

Sheng Lu
  Wenzhou Medical University First Affiliated Hospital: The First Affiliated Hospital of Wenzhou Medical University

Honglin Teng（✉ 907173102@qq.com ）
  Wenzhou Medical College First Affiliated Hospital: The First Affiliated Hospital of Wenzhou Medical University

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Research article

Abstract

Purpose

The purpose of this study was to evaluate the impact of different sarcopenia stages on osteoporotic vertebral compression refracture (OVCRF) and identify other risk factors of new osteoporotic vertebral compression fracture (OVCF).

Methods

We conducted a large, retrospective study of patients who underwent percutaneous kyphoplasty (PKP) for OVCF. Sarcopenia was staged as "presarcopenia", "sarcopenia", and "severe sarcopenia" according to the definition of the European Working Group on Sarcopenia in Older People. Univariate and multivariate analyses evaluating the risk factors for OVCRF were performed.

Results

A total of 329 patients were included, in which 20.4%, 13.1%, and 7.3% of the patients were identified as having "presarcopenia", "sarcopenia", and "severe sarcopenia" respectively. Advanced sarcopenia stage was associated with lower BMI, lower serum albumin level and higher NRS 2002 scores. Subsequent fractures developed in 72 (21.8 %) of 329 patients during the one year follow-up. In univariate analysis, female (p = 0.012), advanced age (≥ 75 years; p = 0.004), lower BMD (p =0.000), stage of sarcopenia (p = 0.009) were associated with OVCRFs. Multivariable analysis revealed that female (OR 6.325; 95% CI 2.176-18.368, p = 0.001), age (OR 1.863; 95% CI 1.002-3.464, p =0.049), lower BMD (OR 1.736; 95% CI 1.294-2.328, p = 0.000), sarcopenia (OR 2.536; 95% CI 1.130-5.692, p = 0.024) and severe sarcopenia (OR 4.579; 95% CI 1.615-12.968, p = 0.004) were independent risk factors of OVCRFs.

Conclusions

Sarcopenia and severe sarcopenia were independent risk factors for OVCRF, as well as low BMD, advanced age and female.

Introduction

Along with the increase of aging population, the elderly osteoporotic vertebral compression fracture (OVCF) incidence also showed a trend of increased gradually. OVCF is a common clinical condition which is characterized by back pain, with limited mobility. Conservative treatment such as bed rest, symptomatic treatment by oral analgesic drugs, will lead to long-term bed complications. For patients with obvious symptoms, percutaneous vertebroplasty (PVP) or percutaneous kyphoplasty (PKP) has become a fine treatment due to its advantages of less trauma, rapid analgesia, and support for early out-of-bed activity in elderly patients [1, 2]. However, with the wide application of this technique, postoperative new vertebral fracture has become a common complication [3, 4], causing secondary pain to patients and

seriously affecting patients' treatment confidence and functional recovery. Therefore, it is important to identify those risk factor for OVCF recurrence and take appropriate interventions.

Sarcopenia is an age-related syndrome characterized by progressive and generalized loss of skeletal muscle mass and strength, associated with functional impairment and disability [5]. Although recent studies have demonstrated that sarcopenia is closely related to osteoporosis [6], the association of sarcopenia and vertebral compression fractures has been rarely investigated. The European Working Group on Sarcopenia (EWGSOP1) has previously classified this condition graded as "presarcopenia", "sarcopenia", and "severe sarcopenia" according to severity [7]. It is assumed that the negative impact of sarcopenia on the clinical outcomes would be more severe with advancing sarcopenia stages. In this study, we applied the EWGSOP2 sarcopenia classification in patients who underwent PKP for OVCF. We aimed to investigate the impact of different sarcopenia stages on osteoporotic vertebral compression refracture and identify other risk factors of refractures.

Methods

From January 2017 to December 2018, consecutive patients who underwent percutaneous kyphoplasty (PKP) for osteoporotic vertebral compression fracture (OVCF) at the Spine Surgical Department of our hospital were included in this retrospective study. The inclusion criteria were as follows: (1) first-ever acute or subacute single-level vertebral compression fracture planned to treated with PKP; (2) underwent preoperative plain film radiography, computed tomography (CT), and magnetic resonance imaging; (3) agreed to take part in the study and signed the informed consent. The exclusion criteria included: (1) previous spinal surgery; (2) pathological fracture, including fractures related to malignancy, infection, or other medical conditions; (3) burst fracture with retro-pulsed bony fragment into the spinal canal and accompanied by neurologic signs before surgery; (4) had complication after surgery, including leakage of cement into the spinal canal, or postoperative neurologic deficit; (5) patients concomitant with severe physical disease who could not adhere to the follow-up visits (had American Society of Anesthesiologists grade≧ Ⅳ); (6) use of steroids; (7) residual back pain(VAS ≧ 4 at 1 month after surgery); and (8) refracture of cemented vertebra. All the patients were prescribed 1-alpha-OH Vitamin D3 (0.5 mcg /day), an active Vitamin D supplement and encouraged to take the medication during 1 year follow-up. The patients were routinely followed up monthly in the outpatient department for the first 3 months after the operation and subsequently at 3-month intervals with regular radiologic studies and osteoporotic medications, or at any point when there was recurrent back pain. New symptomatic fractures was defined as a recurrent back pain and confirmed by MRI. If the patients was lost to follow-up, they would be excluded from our study.

Data collection

For each patient enrolled in this study, the following data were collected: (1) the patient demographic and clinical features, including age, sex, body mass index(BMI), hemoglobin concentration (hemoglobin concentration < 120 g/L for men and < 110 g/L for women was defined as anemia), serum albumin

concentration (serum albumin < 35 g/L was defined as hypoproteinemia), comorbidity, diabetes, American Society of Anesthesiologists (ASA) grade, nutritional risk screening 2002 (NRS 2002) scores, lumber bone mineral density(BMD); (2) vertebral fracture image characters, including the fracture level, cement leakage into the disk, vacuum clefts, fracture severity grade. Fracture level of T5-T10, T11-L2, and L3-L5 were defined as thoracic, thoracolumbar, and lumbar segments, respectively. Bone cement intervertebral leakage were verified by intraoperative and postoperative X-ray. Vacuum clefts were identified with pre-procedural plain radiography, CT and MR imaging. Fracture severity grade was characterized as mild (20%-25% collapse), moderate (26%-40% collapse), or severe (> 40% collapse) according to the semiquantitative classification of Genant et al [8]. Besides, the percentage of vertebral body height collapse less than 20% was defined as "very mild".

Definition of different sarcopenia stages:

The European Working Group on Sarcopenia (EWGSOP1) has recommended that sarcopenia be stratified as "presarcopenia," "sarcopenia," and "severe sarcopenia," based on the severity of this condition [7]. Thus, we classified different sarcopenia stages according to three factor (muscle strength, muscle mass, physical performance) of the updated algorithm proposed by European Working Group on Sarcopenia (EWGSOP2) [9]. "Presarcopenia" is characterized by low muscle strength without the reduction of muscle mass or physical performance; "sarcopenia" is characterized by low muscle strength, plus low muscle mass, "severe sarcopenia" is characterized by low muscle strength, plus low muscle mass and low physical performance; and patients who did not have any of these deficiencies were classified as "normal".

Measurement of muscle strength, muscle mass and physical performance.

A whole body scan for body composition examination was measured with dual energy X-ray absorptiometry (DXA), and appendicular skeletal muscle mass (kg) were recorded. For the EWGSOP2's defnition, low muscle mass (LMM) was defned as having appendicular skeletal muscle mass less than 7 kg/m^2 in men and 6 kg/m^2 in women, respectively [10].

As recommended by the Asian Working Group for Sarcopenia (AWGS), handgrip strength and 6-meter usual gait speed were used for the measurement of muscle strength and physical performance, respectively [11]. Grip strength was measured on the dominant hand using an electronic hand dynamometer (EH101; Camry, Guangdong Province, China). Low handgrip strength was defined as ≤ 26 kg for men and ≤ 18 kg for women; low gait speed was defined as ≤ 0.8 m/s [12]. For the measurement of the 6-m usual gait speed, patients were asked to walk over a 6-m course at their usual speed. Patients were encouraged to mobilize early after PKP, mainly by walking out of bed. These two tests were conducted postoperatively both 1 day and 1 month, and the best value of 3 consecutive tests

was recorded. We used the data of 1 month after surgery, and patients with residual back pain (VAS ≧ 4 at 1 month after surgery) was excluded to avoid interfering with measurement, although no new vertebral fractures have been confirmed by MRI in these patients.

Statistical analysis.

The results are expressed as mean ± SD. The Kolmogorov–Smirnov test was used to determine the normality of continuous data. Statistical significance was evaluated using Student's t-test or one-way ANOVA for continuous normally distributed data. For continuous, non-normally distributed data, the Mann-Whitney U test and Kruskal-Wallis tests were used. Categorical data were compared using the Chi-squared test or Fisher exact test. P<0.05 was considered statistically significant.

To evaluate the risk factors for subsequent fractures, all variables associated with vertebral refractures with P < 0.1 from the univariate analyses were entered into multivariate forward COX regression analysis. Furthermore, Kaplan-Meier analysis was used to determine the cumulative recurrence-free rates according to different sarcopenia stages. All statistical analyses were performed with SPSS for Windows, version 21.0(SPSS Inc., Chicago, IL, USA).

Results

A total of 511 consecutively admitted patients with acute or subacute single-level vertebral compression fracture were screened, and 329 met the entry criteria (Fig. 1). Patient characteristics are summarized in Table 1, the mean age of all the patients was 71.26 years, and the majority of patients (n = 274, 83.3%) were female.

Table 1
Patient demographics and clinical characteristics.

Variable	Total (n = 329)	Normal (n = 195)	presarcopenic (n = 67)	Sarcopenic (n = 43)	Severe sarcopenic (n = 24)	P value
Gender						0.149
Male	55	30	8	10	7	
Female	274	165	59	33	17	
Age (year)	70.96 ± 8.31	69.54 ± 7.83	70.87 ± 8.31	73.33 ± 9.15	78.54 ± 5.37	0.000*
BMI(kg/m2)	23.07 ± 3.53	23.78 ± 3.45	22.81 ± 3.39	21.76 ± 3.34	20.37 ± 2.94	0.000*
Albumin(g/L)	37.16 ± 3.78	37.38 ± 3.57	37.86 ± 3.92	35.81 ± 4.26	35.76 ± 3.40	0.008*
Hemoglobin(g/L)	125.25 ± 13.68	126.07 ± 13.87	124.97 ± 13.61	122.09 ± 13.20	125.04 ± 13.12	0.390
ASA grade						0.131
I	102	62	24	12	4	
II	175	109	32	19	15	
III	52	24	11	12	5	
NRS 2002 score						0.000*
< 3	247	158	49	30	10	
≥ 3	82	37	18	13	14	
Diabetes						0.188
Yes	57	32	10	13	4	
No	272	163	57	31	20	
A-SMI(kg/m2)	6.55 ± 0.57	6.77 ± 0.44	6.57 ± 0.35	5.92 ± 0.57	5.81 ± 0.57	0.000*
Handgrip strength(kg)	21.30 ± 6.18	24.41 ± 5.19	17.57 ± 2.52	16.88 ± 5.14	14.37 ± 6.44	0.000*
Gait speed	0.98 ± 0.16	1.03 ± 0.13	1.03 ± 0.12	0.91 ± 0.10	0.65 ± 0.11	0.000*
BMD(T-score)	-2.94 ± 1.04	-2.79 ± 0.98	-2.93 ± 1.16	-3.37 ± 1.07	-3.40 ± 0.88	0.001*

Variable	Total (n = 329)	Normal (n = 195)	presarcopenic (n = 67)	Sarcopenic (n = 43)	Severe sarcopenic (n = 24)	P value
Treated vertebral level						0.791
T5-T10	50	27	12	8	3	
T11-L2	248	152	48	31	17	
L3-L5	31	16	7	4	4	
vertebral refractures						0.000*
Yes	72	31	14	14	13	
No	257	164	53	29	11	

BMI, Body mass index; ASA, American Society of Anaesthesiologists; NRS, nutritional risk screening; A-SMI, appendicular skeletal muscle mass index

The one-way ANOVA was used to assess normally distributed variables, the Kruskal-Wallis test was used for non-normally distributed variables. The chi-square test or Fisher's Exact test was used for categorical variables.

*statistically significant difference (P < 0.05).

Based on the diagnostic criteria, 67 (20.4%), 43 (13.1%), and 24 (7.3%) of patients were identified as having "presarcopenia", "sarcopenia", and "severe sarcopenia", respectively, whereas 195 (59.3%) of patients were identified as "normal". As is shown in Table 1, the handgrip strength, appendicular skeletal muscle mass index, gait speed significantly lower with advancing sarcopenia stages. Gender, ASA grade, diabetes, and hemoglobin, treated vertebral level did not differ significantly between different sarcopenia stages. Patients with sarcopenia and severe sarcopenia were older, and had lower BMI, lower preoperative serum albumin compared with normal patients, but patients with presarcopenia did not. Patients with presarcopenia, sarcopenia and severe sarcopenia had lower BMD than normal patients. The rate of NRS 2002 score ≥ 3 and the refracture rate increased with advancing sarcopenia stages (19.0% vs 26.9% vs 30.2% vs 58.3%; 15.9% vs 20.9% vs 32.6% vs 54.2%, respectively, P = 000).

In our study, 72 patients (21.9%) had a fracture recurrence. Results of univariate and multivariate analyses for factors associated with osteoporotic vertebral compression refracture (OVCRFs) are presented in Table 2. In univariate analysis, several factors were associated with OVCRFs, including female (p = 0.012), advanced age (≥ 75 years, p = 0.004), lower BMD (p = 0.000), and stages of sarcopenia (p = 0.000). Significant differences were not observed in other factors, including BMI, NRS 2002 score, diabetes, hypoproteinemia, Anemia, ASA grade, Vacuum clefts, treated vertebral level and intradiscal cement leakage and fracture severity grade. Multivariate logistic analysis showed that

sarcopenia (OR 2.536; 95% CI 1.130−5.692, p = 0.024) and severe sarcopenia (OR 4.579; 95% CI 1.615−12.968, p = 0.004), not presarcopenia (OR 1.072; 95% CI 0.509−2.258, p = 0.854) were independent risk factor for OVCRF. Female (OR 6.325; 95% CI 2.176−18.368, p = 0.001), age (OR 1.863; 95% CI 1.002−3.464, p = 0.049), and lower BMD (OR 1.736; 95% CI 1.294−2.328, p = 0.000) were other independent predictors for OVCRFs.

Table 2
Univariate and Multivariate Analysis of Factors Associated With new osteoporotic vertebral compression fractures.

Factors	Univariate analysis			Multivariate analysis	
	OVCRFs group (n = 72)	Non-OVCRFs group (n = 257)	*P* value	*OR (95% CI)*	*P* value
Gender			0.012*		0.001*
Male	5	50		1	
Female	67	207		6.325(2.176–18.368)	
Age (year)			0.004*		0.049*
≥ 75	37	85		1	
< 75	35	172		1.863 (1.002–3.464)	
BMI(kg/m2)			0.547		
< 18.5 kg/m2	7	22			
18.5−24 kg/m2	41	131			
> 24 kg/m2	24	104			
NRS 2002 score			0.062		
< 3	48	199			
≥ 3	24	58			
Diabetes			0.853		
Yes	13	44			
No	59	213			
Hypoproteinemia			0.990		
Yes	19	68			
No	53	189			
Anemia			0.427		
Yes	8	38			
No	64	219			

	Univariate analysis			Multivariate analysis	
ASA grade			0.664		
I	24	78			
II	35	140			
III	13	39			
BMD(T-score)	3.39 ± 1.05	2.82 ± 1.01	0.000*	1.736(1.294–2.328)	0.000*
Vacuum clefts			0.262		
Yes	19	52			
No cleft	53	205			
Treated vertebral level			0.306		
T5-T10	15	35			
T11-L2	50	198			
L3-L5	7	24			
Intradiscal cement leakage			0.986		
Yes	18	60			
No	54	197			
Severity grade			0.180		
Very mild	20	104			
Mild	21	72			
Moderate	20	56			
Severe	11	25			
Stages of sarcopenia			0.000*		0.009*
Normal	31	170		1	
Presarcopenia	15	54		1.072(0.509–2.258)	0.854
Sarcopenia	13	24			0.024*
Severe sarcopenia	13	9		2.536(1.130–5.692)	0.004*
				4.579(1.615–12.986)	

	Univariate analysis	Multivariate analysis

BMI, Body mass index; ASA, American Society of Anaesthesiologists; NRS, nutritional risk screening; OR, odds ratio; CI, confidence interval

The Independent-Samples T test was used to assess normally distributed variables, and the chi-square test or Fisher's Exact test was used for categorical variables. Variables with P < 0.1 from the univariate analyses were entered into multivariate forward logistic regression analysis.

*statistically significant difference (*P* < 0.05).

The time to recurrence event was analyzed by Kaplane-Meier survival curves based on stages of sarcopenia. Patients with sarcopenia and severe sarcopenia had a higher risk of recurrence event compared to patients with presarcopenia and normal patients, P < 0.001; Fig. 2).

Discussion

We enrolled a large sample size to identify the OVCF patients with different stages of sarcopenia according to EWGSOP sarcopenia classification by assessing muscle strength, muscle mass and physical performance. The cut-off values of handgrip strength and 6-meter usual gait speed were according to AWGS because of the eastern people generally have a smaller physique and a lower BMI than the western people. To avoid the effects of pain and movement restriction, handgrip strength and 6-meter usual gait speed were measured post-operation.

The relationship between sarcopenia and vertebral compression fractures has been preliminarily explored. Iolascon et al. [13] confirmed that the rate of sarcopenia increasing along with the number of vertebral fragility fractures in women. A cross-sectional study examined 216 women with fresh OVCF, the result showed sarcopenia were independent risk factors for acute OVCF [14]. However, both two studies definition of sarcopenia only included skeletal muscle mass as the unique parameter. Thus, the sarcopenic patients identified by these studies could have presarcopenia, sarcopenia, or severe sarcopenia. One study in community-dwelling elderly subjects showed that elderly subjects with sarcopenia had a greater risk of falls compared with normal elderly subjects, but those with presarcopenia did not [15]. Another study in women with a hip fracture showed that sarcopenic women had a lower ability to function in their activities of daily living than presarcopenic women [16]. These results demonstrated the value of sarcopenia classification for a better risk stratification. A total of 72 (21.9%) recurrent OVCF occurred during our 1-year follow-up and the refracture rate was increased in advancing sarcopenia patients (20.9% vs 32.6% vs 54.2%, respectively). Our multivariate analysis also demonstrated that sarcopenia, severe sarcopenia were independent risk factors for OVCRF, whereas presarcopenia was not.

The reasons why OVCF recurrence rate increased in advanced sarcopenia stage remain uncertain, the following reasons can be hypothesized. First, a large proportion of fragility fractures in patients with

osteoporosis are reported to be caused by falls [17]. Muscle mass and strength as critical components in maintaining physical function, mobility, and vitality [18]. Low muscle quality would lead to physical disability and frailty, and subsequently increase the risk of falls. Previous studies have reported patients with sarcopenia over 80 - year - old were approximate three times to have a fall than non-sarcopenia patients within two years [19]. Second, advanced sarcopenia stage was associated with a lower BMD in the present study(Table 1,P = 0.007). Two large sample data study confirmed sarcopenia was associated with osteopenia and osteoporosis in Asian area [20, 21]. For patients with low BMD, the quality of the vertebral bodies was poor, resulting in a greater probability of OVCRF. Bone and muscle are not only adjacent to each other in anatomy, but also indispensable in basic metabolism. Recently, it has become clear that bone and muscle share genetic determinants [22]. The close interaction between bone loss and muscle wasting results in the co-occurrence of osteoporosis and sarcopenia, named osteosarcopenia [23]. Furthermore, some researchers have found a synergistic effect between osteoporosis and sarcopenia, lead to the occur of fragility fracture [24].

Low bone mineral density is another risk factor for recurrent fractures in this study. The average T-score was − 3.4 in patients with subsequent fractures and − 2.8 in patients without subsequent fractures group. Young-Joon Rho et al. [25] regard osteoporosis as the most important risk factor for additional fracture. However, Compared with BMD (OR 1.736; 95% CI 1.294−2.328, p = 0.000), sarcopenia (OR 2.536; 95% CI 1.130−5.692, p = 0.024) and severe sarcopenia (OR 4.579; 95% CI 1.615−12.968, p = 0.004) had greater odds ratio in the multivariate model. We therefore concluded that sarcopenia, severe sarcopenia had much stronger prediction power for the occurrence of postoperative OVCRF than BMD.

Advanced sarcopenia stage was associated with lower BMI (P = 0.000), lower serum albumin level (P = 0.008) and higher NRS 2002 scores (P = 0.000) in the present study(Table 1), both of which are common index to evaluate nutritional status. Lin WC et al reported that low BMI was a significant predictor of new VCFs after vertebroplasty, especially if the BMI was less than 22 kg/m [26]. However, none of the traditional nutritional indices, such as BMI, albumin levels and NRS 2002 scores, were associated with OVCRF. We speculated that sarcopenia is a more comprehensive parameter than these traditional nutritional indices, reflecting not only the nutritional status but also the functional status. Moreover, skeletal muscle mass has been reported to be a new index for nutritional assessment [27]. Existing research has focused more on anti-osteoporosis treatment to prevent recurrence of fractures [28, 29], the present study indicated that anti-sarcopenia could be regarded as a potential therapeutic target in the future. We think resistance training program such as knee extension/flexion and leg presses to offset sarcopenia could be carried out at the appropriate time after surgery. Adequate nutritional intake and certain nutritional supplements, such as leucine and omega-3 polyunsaturated fatty acids, could have a synergistic effect with resistance training in maintaining muscle mass [30].

Age and sex were statistically significant difference between the OVCRFs group and non-OVCRFs group in univariate analysis. Other risk factors like treated vertebral level, vacuum clefts, intradiscal cement leakage, and AP ratio showed no difference between the two groups, which were still controversial [25, 31, 32]. Meanwhile, multivariate analysis revealed that female (OR 6.325; 95% CI 2.176−18.368, p = 0.001)

and older age (OR 1.863; 95% CI 1.002–3.464, p = 0.049) were related to OVCRFs after PKP in our study. As people getting older, the quantity and mass of trabeculae will decrease simultaneously. The absorption of calcium in the digestive system decreases at the same time, leading to the loss of bone mass in elderly patients, especially postmenopausal women [33, 34]. Lidsay et al. [35] observed that almost 20% of women would experience another fracture within 1 year of an incident vertebral fracture.

The present study was strengthened by its large sample retrospective study design, the strict inclusion and exclusion criteria, and rigorous follow-up strategy. Our department is one of the largest spine centers in China, performing > 400 OVCF operations annually, which enabled the study to be finished within a short time range. However, there are still several limitations. First, this is a single-center study, the conclusions of this study need to be validated in multicenter studies in the future. Second, only symptomatic subsequent fractures were included. The actual subsequent fractures rate would be higher than the observed rate. Third, there were differences in the use of anti-osteoporosis drugs during postoperative follow-up, which may resulted in a biased refracture rate.

Conclusion

In conclusion, symptomatic subsequent fractures occurred in 21.8% of the patients with first-time and single-level fractures during the year following PKP treatment. This study demonstrated that patients had higher OVCRF rate with advancing sarcopenia stages. Sarcopenia and severe sarcopenia were identified as independent risk factor for OVCRF, whereas presarcopenia was not.

Low BMD T-scores, advanced age and female are other risk factors for OVCRF. Our work emphasized the value of recognizing sarcopenia stages, in terms of performing a better risk stratification, as well as helping to set an appropriate strategy to avoid recurring fractures.

Abbreviations

OVCF: osteoporotic vertebral compression fracture; OVCRF: osteoporotic vertebral compression refracture; PVP: percutaneous vertebroplasty; PKP: percutaneous kyphoplasty; EWGSOP: European Working Group on Sarcopenia; BMI: body mass index; ASA: American Society of Anesthesiologists; NRS: nutritional risk screening; BMD: lumber bone mineral density; DXA: dual energy X-ray absorptiometry; LMM: low muscle mass; AWGS: AWGS Asian Working Group for Sarcopenia; VAS: Visual analogue scale/score

Declarations

Authors' contributions

All authors contributed to the study conception and design. Chao-wei Lin, Min-yu Zhu, Sheng Lu collected the data. Ke-lun Huang and Hong-lin Teng analyzed and discussed the results. All authors read and approved the final manuscript.

Availability of data and materials

Datasets are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Medical Ethics Committee of the First Affiliated Hospital of Wenzhou Medical University. Written informed consents were obtained from patients or their relatives.

Consent for publication

Consent for publication was obtained from the patients or their relatives.

Competing interests

The authors declare that they have no competing interests.

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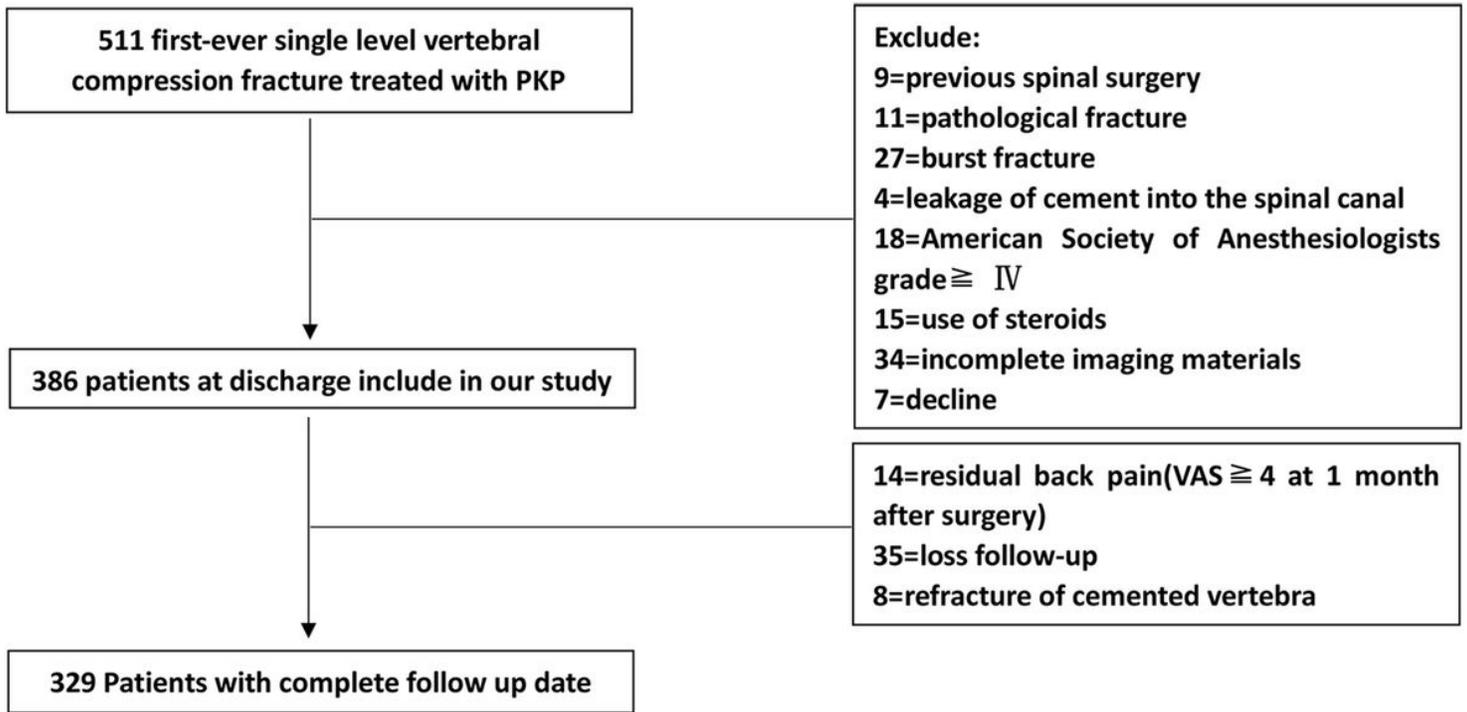
Figures

Figure 1
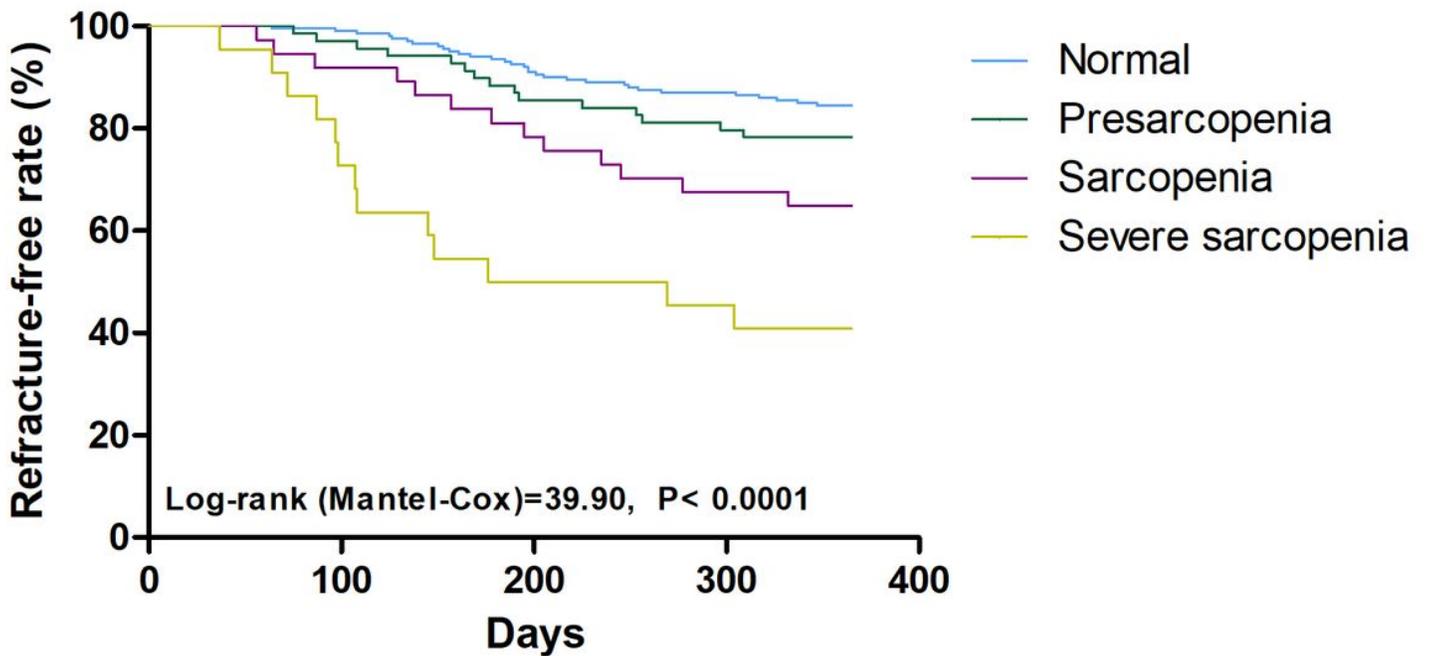
Study profile/flow sheet of the study.

Figure 2

The time to recurrence event was analyzed by Kaplane-Meier survival curves based on different sarcopenia stages. Patients in the upper two quartiles (normal and presarcopenia) had a minor risk of recurrence event compared to patients with advanced sarcopenia stages in the lower two quartile(sarcopenia and severe sarcopenia).